GEOTECHNICAL ENGINEERS INC.

PRE-ANALYSIS OF PROPOSED GEODETIC NETWORK AT BALL MOUNTAIN DAM JAMAICA, VERMONT

U.S. Army Corps of Engineers
New England Division

May 20, 1986

Submitted to

U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254-9149

by

Geotechnical Engineers Inc.
1017 Main Street
Winchester, Massachusetts 01890
(617) 729-1625

Project 85769

Prepared by

Boston Survey Consultants
Boston, Massachusetts

Stephen L. Whiteside, P.E.
Project Manager

Ronald C. Hirschfeld, P.E.
President

The BSC Group

PREANALYSIS OF PROPOSED GEODETIC NETWORK AT BALL MOUNTAIN DAM VERMONT

MAY 1986

450 Summer Street
Boston MA
02210

The BSC Group

May 20, 1986

617 350 4090

Mr. Stephen L. Whiteside, P.E.
Geotechnical Engineers, Inc.
1017 Main Street
Winchester, MA 01890

RE: Preanalysis of Proposed Geodetic Network
Ball Mountain Dam, VT

Dear Steve:

I am pleased to submit the attached report in connection with the above-referenced project.

The results outlined in the report indicate that required accuracy can be achieved.

Sincerely

THE BSC GROUP
Boston Survey Consultants

Kevin Hanley

Kevin Hanley, P.L.S.
Division Manager

Engineers
Surveyors
Scientists
Architects
Landscape Architects
Planners

KH/gh

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EXECUTIVE SUMMARY

In accordance with our contract with Geotechnical Engineers Inc., Winchester, Massachusetts, Boston Survey Consultants (BSC) has prepared this pre-analysis of the Proposed Monitoring Sueveys for the Ball Mountain Dam, Vermont.

The nature of the dam and the natural topography is such that the implementation of a classical geodetic framework is not possible. Thus additional observations points must be included in the geodetic network to:

(a) strengthen the framework and

(b) ensure adherence to the accuracy requirements

The report prepared by Dr. Adam Chrzanowski in conjunction with Mark Rohde at the University of New Brunswick indicates that the level of accuracy required can be attained using the instrumentation and targetting proposed by BSC. As with any precision measurement survey extreme care is required. The design of the measurement approach is addressed in Section 4 and recommendations as to observing methodology have been suggested in order to attain the required accuracy.

REPORT

PRE-ANALYSIS OF PROPOSED MONITORING SURVEYS FOR THE BALL MOUNTAIN DAM ON THE WEST RIVER, VERMONT

Prepared for The BSC Group by
Dr. A. Chrzanowski, P.Eng., J. Secord and M. Rohde

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1. INTRODUCTION

According to the letter of 25 November 1985, the following scope of services was requested:

1. Review topographic plans and photographs of the project site in order to determine preliminary location of the geodetic network. In addition, if deemed necessary, a site visit should be undertaken.
2. Perform a pre-analysis of the network to determine changes required in the network design to meet required accuracies, to predict probable accuracies based on the proposed instrumentation and to develop an observational methodology to achieve the required accuracies.

The topographic plans and photographs were supplied by Mr. Mark Rohde who had already visited the site under the employment of BSC in August 1985. Although a visit by these consultants was deemed necessary, the time constraint imposed by BSC for the results of the pre-analysis to be delivered by 29 November 1985 required that only the immediately available information could be utilized. The information consisted of:

i) Photographs of the dam and its environs;
ii) Proposed geodetic network overlayed on a Corps of Engineer's General Plan of the dam at a scale 1" = 100';

iii) Proposed layout of instrumentation at a scale 1" = 50';

iv) Survey instrumentation to be used which consists of:

Wild T3 or T2000 theodolites,

Wild DI4L EODM instrument,

Wild traversing targets,

v) Verbal information on the proposed monumentation which would allow (in most cases) for self-centering of the instruments and targets ;

vi) Verbal communication that the expected movement of the dam would be 3 mm per month.

2. APPROACH TO THE PRE-ANALYSIS

The pre-analysis for deformation surveys requires greater computational effort and more sophisticated procedures than for conventional geodetic surveying.

Over the past five years a generalized method (called the UNB Generalized Method) for the analysis of deformation surveys has been developed in the Department of Surveying Engineering at the University of New Brunswick which allows a versatile treatment of such surveys with possible integration of any type of observables, not only geodetic but also geotechnical, such as tilt, strain and other physical measurements. This method is described in Appendices 4 and 5, and has been applied in several geotechnical projects such as: monitoring of dyke deformations in oil fields in Venezuela, dam deformation studies at Mactaquac, N.B., tectonic deformations in Peru and ground subsidence studies in coal mining areas in Western Canada to name only a few. The generalized approach allows determining not only single point displacements but also more general deformation parameters such as strain components and relative rigid body motion. In this particular application in the pre-analysis for monitoring the deformation of the Ball Mountain Dam, only the detection of single point displacements on the dam structure and in the reference network was

considered. One should emphasize that in deformation studies a treatment of reference points as fixed and errorless is incorrect, particularly in the case of the Ball Mountain Dam where the aperture of the reference network is small, about 400 m, and the points are close to the reservoir.

The changeable water level of the reservoir may induce ground movements to a considerable distance from the dam structure. In addition, the possible local movement of the survey monuments (frost action, thermal deformations, etc.) cannot be ignored. Therefore, in the UNB Generalized Method, after at least two campaigns of survey, the detection of unstable points in the reference network is done first through a trend analysis and later in the overall analysis the unstable reference points are treated as additional object points. In the course of pre-analysis one cannot predict which of the reference points may be unstable. Therefore, a provision must be made when designing the accuracy of the survey that the relative positions of the reference points must be determined with, at least, the same or better accuracy than is the tolerance for detecting the movements of the object points.

In the UNB Generalized Method, the modelling of movement is derived by least squares fitting of a selected displacement function to the displacement field incorporating all the points within the network and their associated variances and covariances. In turn, the displacement field results from the combination of two or more campaigns of observation. Pre-analysis and the designing for detection of movement follow the same path, from the observation field through the displacement field to the parameter space describing the movement. Algorithms for the analysis and design (pre-analysis) have been developed (Chen, 1983) and implemented in the Department (Secord, 1984) and were utilized in this design.

Since the displacement of 0.003 m in either the horizontal or the vertical direction is to be detected by monthly surveys, the pre-analysis has recognized a value of $\pm$ 0.003 m as a tolerance at the 0.95 level of confidence. This tolerance imposed the limit on the detection of displacement in x, y, or z between two campaigns. Hence, into a single campaign of horizontal survey (i.e. separating x, y movement), this tolerance becomes a standard deviation of

$$\frac{\pm 0.003}{2.4484\sqrt{2}} = \pm 0.0008 \text{ m}$$

and in the vertical (z movement only), the tolerance translates into a standard deviation of

$$\frac{\pm 0.003}{1.96\sqrt{2}} = \pm 0.0011 \text{ m}$$

for positioning in a single campaign.

After examination of the above material, the consultants decided that for the purposes of pre-analysis the geometry of the monitoring network as proposed by BSC could be accepted without any major changes except for the relocation of one reference point (point P3 on the attached plan of the network) from which the targets on the dam structure should be visible. Also one target point was added on the intake tower so that the stability of that structure should be included in the study. As far as the type of observables to be used in the monitoring surveys was concerned, direction measurements with the Wild T2000 have been favoured in the pre-analysis with only a few distances to be measured for the control of the scale of the reference network.

The pre-analysis of the vertical movements was based on the assumption that the vertical movements will be determined by trigonometric height traversing by measuring zenith angles to the targets on the dam and

between all reference points and by using distances and their variances derived from the adjusted coordinates obtained from the horizontal surveys.

Special attention has been paid to the influence of the possible changes in atmospheric refraction between the survey campaigns. The commonly accepted value of the coefficient of refraction k = 0.13 is valid only for the lines of sight passing above the ground surface at 40 metres or higher. In the first few metres above the ground the coefficient may reach the value of -10 or even more (Chrzanowski, 1985) with significant seasonal changes, which may be the case in the project area. For instance, if over an average distance of 200 m the value of k would change from 0 to -2 which is quite likely, the height difference determination would change by 6 mm.

3. RESULTS OF THE PRE-ANALYSIS

3.1 Pre-analysis of Horizontal Movements

A preliminary pre-analysis involved several variants on the types and number of observables to be used within the given geometry of the network. The finally accepted scheme is shown in Fig. 1 in which the 6 reference points and 28 object points (including the Tower target as an object point) are connected by 103 directions observed from reference stations: P1, P2, P3, P4, and P5 (only P6 being not occupied) and only 4 distances observed from station P4 as shown by heavy lines in Fig. 1. Apparently, preliminary pre-analysis has shown that the variants on the distribution (localization) of the few measured distances in the network did not alter significantly the result of the pre-analysis. The choice of having the deformation surveys relying mainly on direction measurements rather than distances was made on the basis of the available

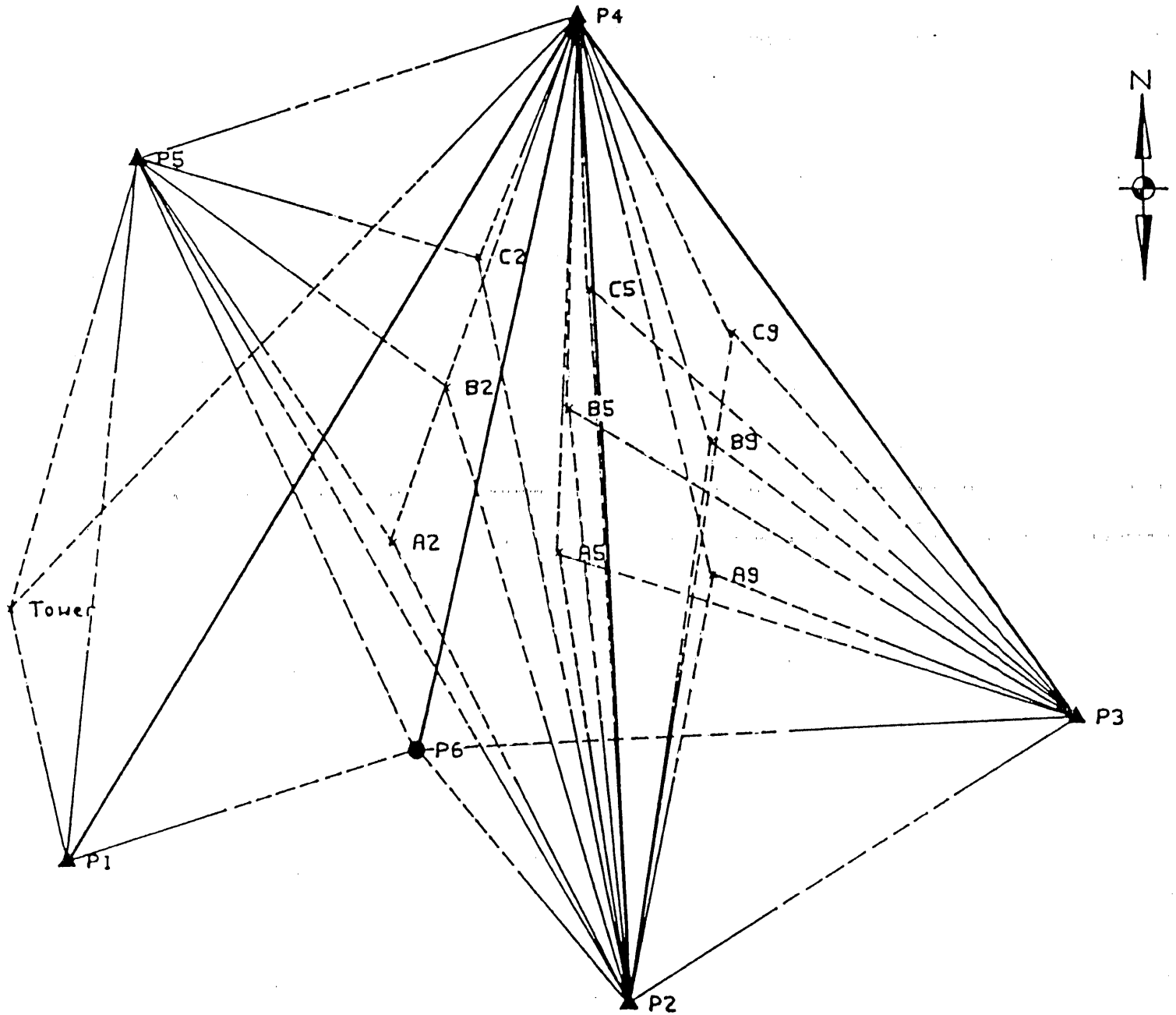

Figure 1 Network & Scheme as considered in Pre-analyses

instrumentation and their precision, topography and, connected with it, logistics in placing retroreflectors on too many points.

Due to the very limited time allowed for the pre-analysis, only 10 object points were included in the computations as representative of the likely result for all of the other points. The approximate coordinates (x, y, z) of all the analysed points were determined from the attached plan using a local x, y coordinate system and the contours.

The pre-analysis was done in the following steps using the UNB software for the Generalized Method:

i) Determination of variances and covariances of coordinates of all the points through the propagation of accepted variances of observations holding one point and one direction in the network fixed and errorless (minimal constraints). One should emphasize that in the UNB Generalized Method the choice of the minimal constraints is irrelevant because the modelled movements are datum independent.

ii) Determination of the relative error ellipses (all combinations) for a preliminary evaluation of the detectability of relative point movements.

iii) Modelling of deformation, which in the case of single point movements is very simple; for each reference point the model is $dx_i = 0$ and $dy_i = 0$ with their appropriate variances and covariances and for the object points, $dx_i = a_i$ and $dy_i = b_i$ where a and b are to be determined through the least squares fitting of the model to the observed displacements. In the pre-analysis, only the variances and covariances of the a_i and b_i parameters are determined.

iv) Depiction of the error ellipses corresponding to the variance and covariance of the a_i and b_i, for the displacements of the object points at the 0.95 confidence level and their comparison with the accepted tolerance (0.003 m in this project).

The final pre-analysis was made for the following 3 different accuracies of observations:

Analysis No. 1: direction measurements $\sigma = \pm 1''$

distance measurements $\sigma = \pm 5$ mm ± 5 ppm

Analysis No. 2: direction measurements $\sigma = \pm 0.5''$

distance measurements $\sigma = \pm 5$ mm ± 5 ppm

Analysis No. 3: direction measurements $\sigma = \pm 0.5''$

distance measurements $\sigma = \pm 3$ mm ± 2 ppm

Results of steps i) and ii) above for the three variants of the pre-analysis are given in Appendices 1 to 3. The results of step iii) are shown in Table 1 and the final results, the error ellipses of the displacements with respect to the block of all the reference points, are shown in Figures 2 to 4.

The final results indicate that if the displacements would be expected to take place only in the down- and up-stream direction, the accuracies of the observations in Analysis No. 1 would be sufficient because the displacements of 3 mm would extend beyond the 95% error ellipses. However, if the detectability of the 3 mm movement would be required in all directions, then the accuracies of observations should be, at least, as accepted in Analysis No. 2 or even Analysis No. 3.

3.2 Pre-analysis of Vertical Movements

The pre-analysis followed the same steps as the analysis of the horizontal movements using approximate heights of the points as determined from the topographic plan. Of course, error ellipses do not apply to the unidimensional case. The same number of zenith angles as horizontal directions (observed simultaneously from the same stations) has been taken

Table 1. Standard Deviations of Single Point Rigid Body Displacement Components

Point	Standard deviation in x component (a_i)	Standard deviation in y component (b_i)	
A2	± 0.0011 m	± 0.0021 m	*
	0.0006	0.0010	**
	0.0006	0.0010	***
A5	0.0010	0.0017	
	0.0005	0.0008	
	0.0005	0.0008	
A9	0.0010	0.0012	
	0.0005	0.0006	
	0.0005	0.0006	
B2	0.0009	0.0013	
	0.0004	0.0006	
	0.0004	0.0006	
B5	0.0009	0.0020	
	0.0005	0.0010	
	0.0005	0.0010	
B9	0.0011	0.0018	
	0.0005	0.0009	
	0.0005	0.0009	
C2	0.0007	0.0009	
	0.0004	0.0005	
	0.0004	0.0005	
C5	0.0008	0.0026	
	0.0004	0.0013	
	0.0004	0.0013	
C9	0.0014	0.0025	
	0.0007	0.0012	
Tower	0.0007	0.0022	
	0.0003	0.0011	
	0.0003	0.0011	

* directions ± 1.0" distances ± 0.005 m ± 5 ppm
** directions ∓ 0.5" distances ∓ 0.005 m ∓ 5 ppm
*** directions ∓ 0.5" distances ∓ 0.003 m ∓ 2 ppm

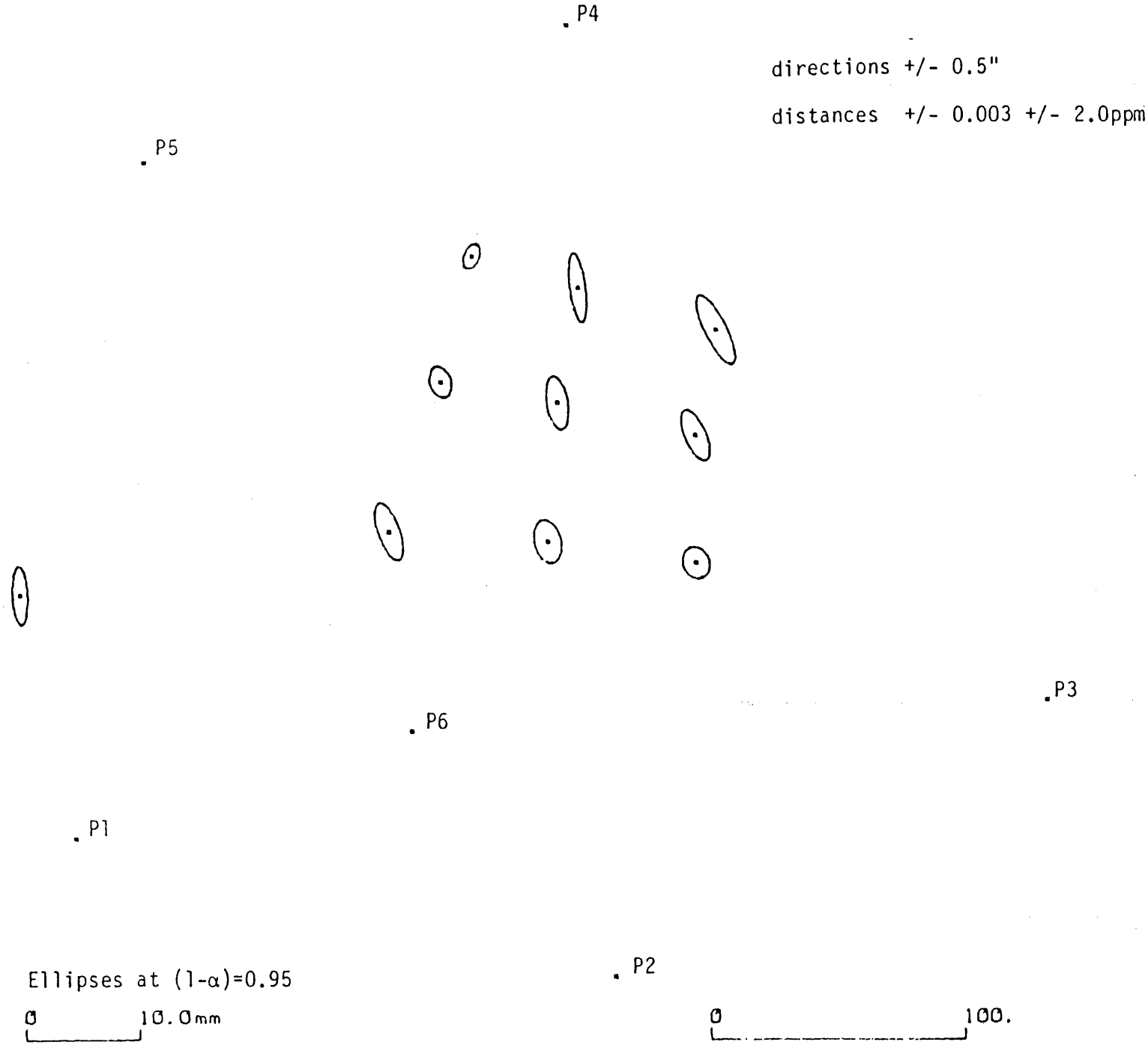

Figure 4 Analysis No. 3 Single Point Rigid Body Movement Error Ellipses

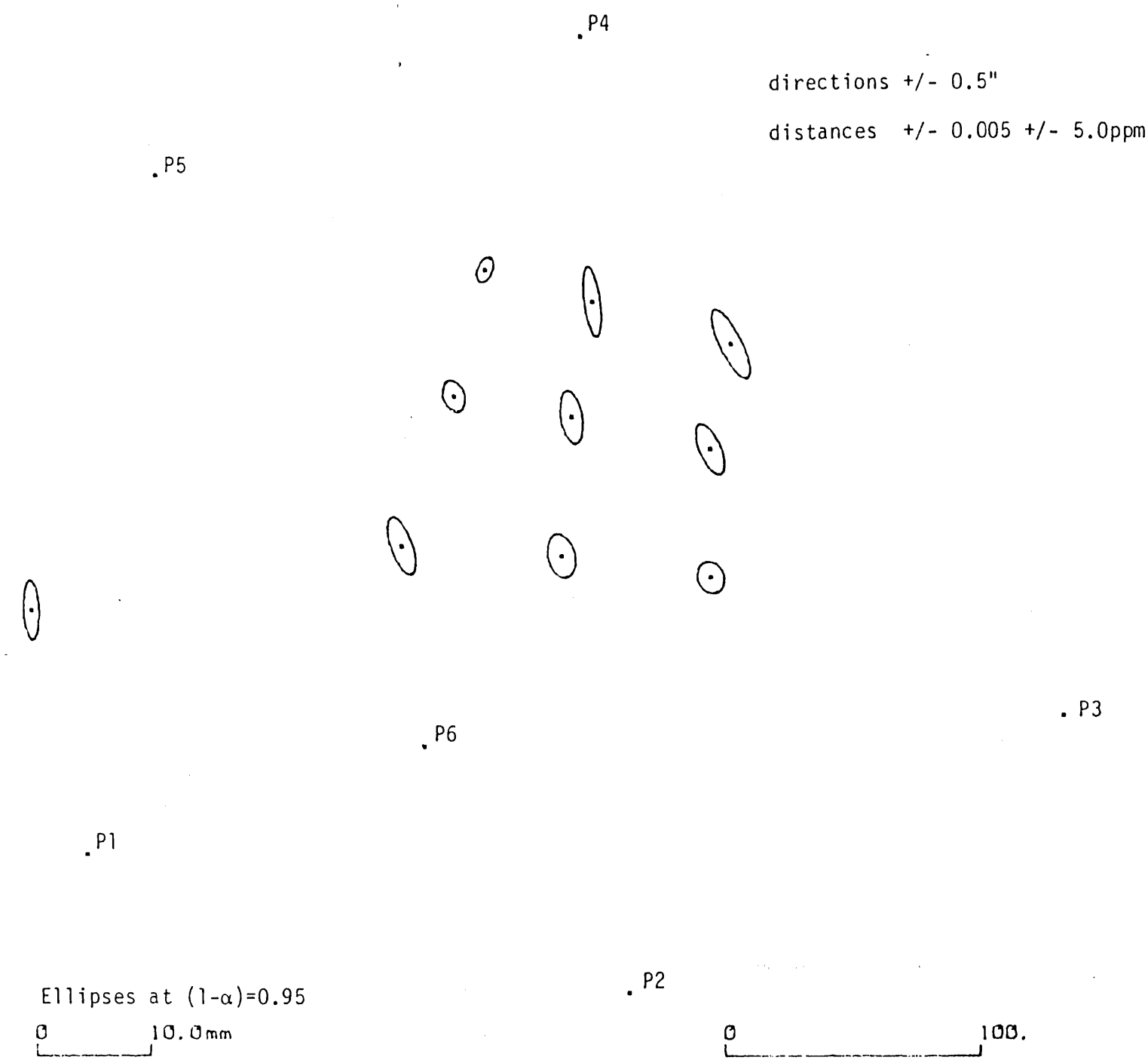

Figure 3 Analysis No. 2 Single Point Rigid Body Movement Error Ellipses

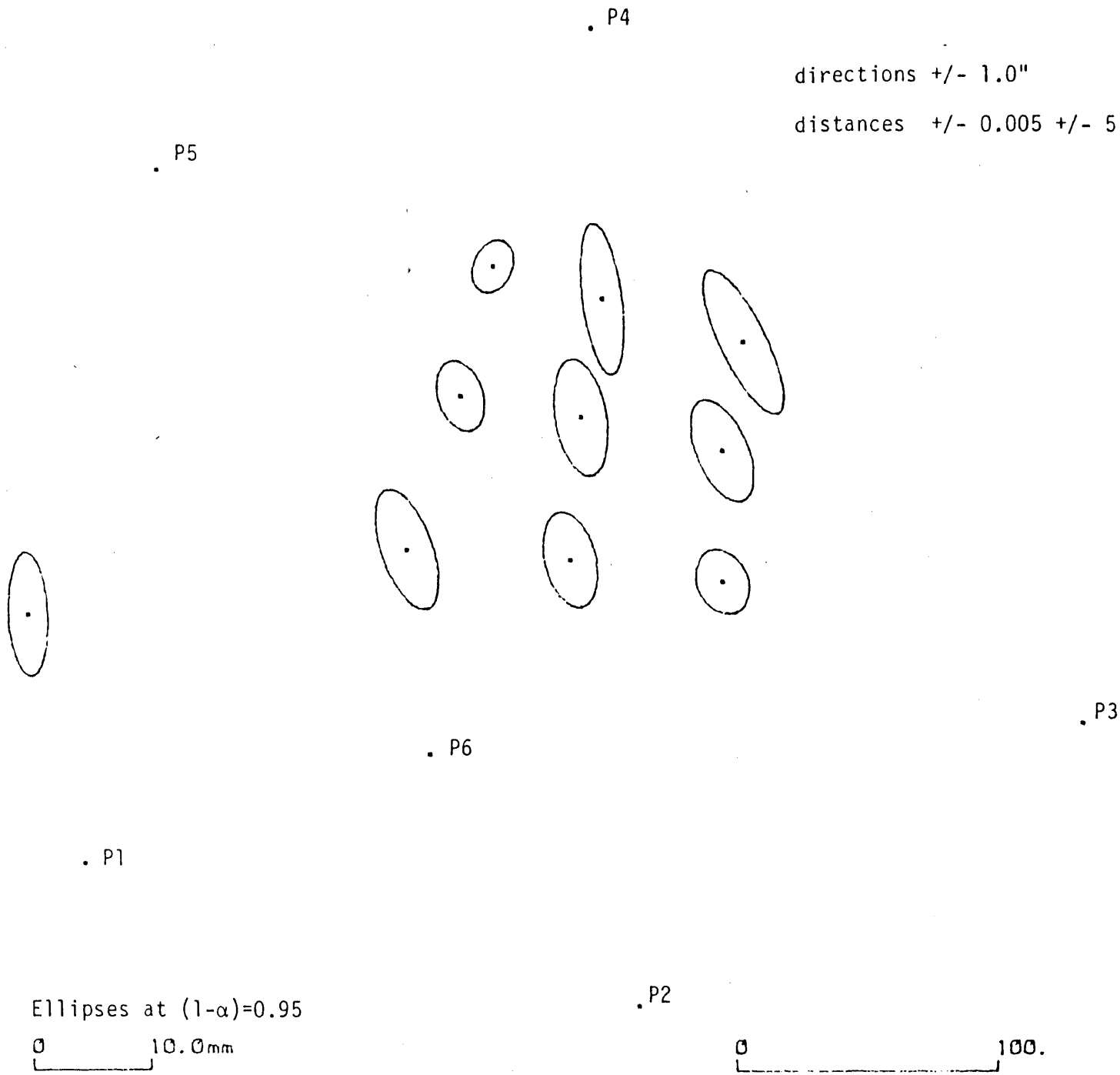

Figure 2 Analysis No. 1 Single Point Rigid Body Movement Error Ellipses

in the pre-analysis. Only one pre-analysis was made using σ = 0.7" for zenith angles and distances derived from adjusted coordinates with variances and covariances as obtained from the pre-analysis of the horizontal network (analysis No. 2). In addition, errors of the coefficient of refraction were taken as $\sigma_k = \pm 0.5$ on those lines along which the terrain profile significantly goes downwards near the instrument station and $\sigma_k = \pm 1$ along other lines.

Table 2 lists the errors in vertical displacements at the 0.95 confidence level as obtained from the pre-analysis. As one can see the accuracies marginally meet the tolerance limit of 3 mm. It depends, of course, how well the atmospheric refraction will be known during the survey campaigns. Since this is difficult to predict, any additional pre-analysis with other accuracies of angle measurements would not be helpful. Some recommendations for controlling the effects of refraction are given in the next section.

4. DESIGN OF MEASUREMENTS

4.1 Horizontal Network

The design of measurements for detecting horizontal movements has been based on pre-analysis No. 2 which calls for directions to be measured with a standard deviation of 0.5" and distances with the standard deviation of $\pm$ 5 mm $\pm$ 5 ppm. These accuracies are achievable with the equipment available to the BSC Group, namely the electronic theodolite Wild T2000 and DI4L EODM instrument if certain conditions are satisfied.

Based on the extensive experience of these consultants (Chrzanowski, 1985) with the use of the T2000 and on the error analysis of pointing, reading, levelling and centering (Chrzanowski, 1984 and Chrzanowski, 1977), the accuracy of 0.5" is achievable if:

Table 2. Confidence Intervals at 0.95 for the Vertical Displacement Component

Point	Confidence Interval
Tower	0.99 mm
A2	2.91
A5	3.15
A9	3.06
B2	2.56
B5	3.00
B9	3.19
C2	2.28
C5	2.59
C9	3.02

a) directions are measured in four sets (two positions of the telescope in each set;

b) centering of the theodolite and of the targets (in the case of this project) is done with an accuracy better than 0.3 mm;

c) levelling of the instrument, for measurements with inclination of lines up to 5°, with an accuracy better than 5" (achievable with a properly adjusted spirit level) and for inclinations up to 20° with an accuracy better than 1" which is achievable only when using the compensator of the vertical circle for levelling the instrument and when relevelling the instruments between individual sets;

d) using specially designed targets (Blachut et al., 1979);

e) shading the instrument from direct solar radiation.

Since the measurements will be performed on pillars equipped with some kind of forced centering plates, point b) above should be easily satisfied with properly designed targets and their mountings. Since the BSC group decided to use Wild traversing targets, these consultants strongly recommend checking all the targets (at close range) for their centricity with respect to their axes of rotation and axes of the mounting device. Since P6 will require centering of targets and retroreflectors on a tripod, an additional rotatable optical plummet (available from Wild) should be used. Otherwise, the optical plummet which is built into the Wild tribrachs should be carefully adjusted before each campaign and the centering of the target should be repeated between sets of angle measurements after rotating the tribrach on the tripod by 90°, each time.

Point c) above is extremely important in the case of steep lines of sight. For example, an error of 5" in levelling (which is only 1/4 of one division of the spirit level in T2000) in the direction of the trunnion

axis will cause an error of 1.8" in direction measurement if the line of sight is inclined 20^{0}. The use of the compensator of the vertical circle may give the accuracy better than 1" in levelling the instrument. Here, a theodolite such as Kern E2 would be more convenient because it has a double compensator and provides automatic correction to the measured directions due to mislevelling of the instrument.

Regarding point d) above, these consultants would recommend using custom-made, special targets of a conical shape. They could certainly provide better pointing accuracy than the standard Wild targets which are not made for high precision engineering surveys. The custom-made targets would provide an additional advantage in that they would not require their rotation when sighting from different directions and hence decrease the required manpower. If the decision on the use of the Wild targets cannot be changed, the targets will have to be carefully checked and, the results of the first campaign, may indicate that the number of pointings will have to be increased.

The above specifications may prove to be either too rigorous or too lax. Only an a posteriori analysis of the results of the first campaign will show what changes in the field procedures will be needed in the subsequent campaigns. It depends on the experience and care of the survey crew as well as the actual physical conditions at the time of measurement.

The requirement of $\pm$ 5 mm $\pm$ 5 ppm should be satisfied by the Wild DI4L instrument but only when the instrument is carefully calibrated prior to the first campaign and at least once in the middle and once after completing the project, for cyclic error, zero error and scale. Due to the comparatively short distances involved, the pointing of the instrument is

very critical because it may easily change the strength of the returning signal and introduce a bias into the phase measurements. It is recommended to take at least 15 readings of the EDM with separate electronic pointings to the reflector before each group of 5. Though the distances are short, use of good quality calibrated barometers and thermometers is recommended for meteorological corrections because some pocket barometers show errors as large as 20 mb which could introduce a significant change in scale of the measured distances and, consequently distort the deformation analysis. The scale calibration must be made on a calibrated baseline against measurements with more accurate instruments such as Kern Mekometer, Geomensor or, at least, Tellurometer MA100. Heights of the retroreflector on the tripod at P6 should always be measured to $\pm$ 0.001 m for the distance reductions.

Any calibration yields corrections to the instrument output that pertain to a specific EODM instrument and retroreflector combination. Ideally, the same combination should be used for each campaign, but if this is not possible, then calibration must be done for each combination before and after each campaign.

4.2 Design of Trigonometric Height Traversing

The vertical angle measurements, in order to achieve the 0.7" standard deviation must follow practically the same specifications as listed in 4.1 for horizontal directions. These would be easily met since the T2000 provides a simultaneous measurement of the horizontal and vertical circles. Shading of the instrument is extremely important.

Care must be taken that the heights of the theodolite and of the targets are the same in all campaigns or measurements of these heights must

be made with an accuracy better than 1 mm. This may be difficult to achieve on P6 where the target will be on a tripod. An auxiliary spirit level with a levelling staff could be used to measure the height of the target in each campaign.

As it was mentioned, the possible changes in the coefficient of refraction may cause major problems in achieving the required vertical accuracy. Reciprocal and simultaneous measurement of the vertical angles could decrease the refraction effect. However, this would significantly prolong the survey campaign and it would require additional instrumentation and its adaptation (Chrzanowski, 1985). Perhaps, as another possible remedy, these consultants recommend measuring gradients of temperature in the vicinity (say $\sim$ 20 m in front of the instrument) near the instrument station along the lines of sight. The instrumentation for that purpose is available at UNB. From the changes of the gradients one could easily estimate the refraction error and even calculate approximate corrections (Chrzanowski, 1984).

5. CONCLUSIONS AND RECOMMENDATIONS

The main conclusion is that the required accuracy of 3 mm in detecting the dam movement can be met with the instruments available to the BSC group, namely the T2000 theodolite and DI4L EDM instrument. The use of the Wild targets may cause some problems. However, the analysis of the first campaign will provide sufficient evidence whether the desired accuracy can be met with these targets. If not, a redesign of the survey in the next campaign should not be difficult. UNB will gladly assist in the analysis of the survey.

It is estimated that the proposed survey scheme should allow completing one campaign in about 2 1/2 days by a survey crew of 3 if an electronic data collector would be available for the T2000. Practically, any microcomputer can easily be interfaced with the T2000. These consultants successfully used the TRS80 Model 100 and EPSON HX20 microcomputers. They are inexpensive ($\sim$ \$1000 with printer and cassette recorder). They could provide a real-time check of the field data and even direct comparison of the measured angles and distances with previous campaigns. This would make the whole project run more smoothly and more economically. UNB could develop all the necessary software.

UNB has a Kern E2 theodolite with DM502 EDM instrument ($\pm$ 3 mm $\pm$ 2 ppm) interfaced with the TRS 80 Model 100 microcomputer. The use of the system could be made available to the project. Also one very experienced research assistant could participate in the field surveys. As mentioned before, UNB has instrumentation and expertise in the measurements of the gradients of temperature.

The UNB baseline (1.6 km long with 6 pillars and accuracy $\pm$ 1 mm) could be used for the calibration of the EDM equipment. All the software necessary for the processing of the calibration measurements (on any baseline) has been implemented at UNB.

The analysis of the deformation surveys could efficiently be made using the UNB Generalized Method. The Method would allow integrating the analysis of the geodetic surveys with the intended borehole measurements by inclinometers (Chrzanowski et al., 1985). There is no other method available which allows for such an integrated analysis. This would be very valuable for geotechnical engineers who will be in charge of the interpretation of the monitoring surveys.

6. REFERENCES

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1

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*****************************************************************************************************
*                                                                                                   *
*          BALL MOUNTAIN DAM, VERMONT  1.0; 0.005,5.0                                               *
*                                                                                                   *
*****************************************************************************************************
                                   THU, NOV. 28, 1985    15:47:54

                                  O P T I O N S   I N   E F F E C T
                                  ---------------------------------

PREANALYSIS OR ADJUSTMENT ........................................ PREANALYSIS

FIXED STATIONS                    WEIGHTED STATIONS                BLAHA STATIONS
   P1

CONVENTIONAL LINEAR UNIT ..................................................... METRE
```

Appendix 1

INITIAL APPROXIMATE COORDINATES

FREE STATIONS:

STATION	X (E)	Y (N)
P2	304.8000	21.3000
P3	474.0000	129.5000
P4	289.6000	390.1000
P5	128.0000	335.3000
P6	228.6000	115.8000
TOWER	77.7000	169.2000
A2	219.5000	192.0000
A5	280.4000	187.5000
A9	338.3000	181.4000
B2	242.3000	249.9000
B5	288.0000	240.8000
B9	338.3000	231.6000
C2	254.5000	300.2000
C5	295.7000	286.5000
C9	347.5000	272.8000

FIXED STATIONS:

STATION	X (E)	Y (N)
P1	97.5000	76.2000

SUMMARY OF INPUT OBSERVATIONS AND THEIR STANDARD DEVIATIONS:

	AT	FROM	TO	STD.DEV
DISTANCE	P4	P4	P3	0.005
DISTANCE	P4	P4	P2	0.005
DISTANCE	P4	P4	P6	0.005
DISTANCE	P4	P4	P1	0.005
DIRECTION 1	P1	P1	TOWER	1.00
DIRECTION 2	P1	P1	P5	1.00
DIRECTION 3	P1	P1	P4	1.00
DIRECTION 4	P1	P1	P6	1.00
DIRECTION 1	P2	P2	P6	1.00
DIRECTION 2	P2	P2	P5	1.00
DIRECTION 3	P2	P2	A2	1.00
DIRECTION 4	P2	P2	B2	1.00
DIRECTION 5	P2	P2	C2	1.00
DIRECTION 6	P2	P2	A5	1.00
DIRECTION 7	P2	P2	B5	1.00
DIRECTION 8	P2	P2	C5	1.00
DIRECTION 9	P2	P2	P4	1.00
DIRECTION 10	P2	P2	B9	1.00
DIRECTION 11	P2	P2	C9	1.00
DIRECTION 12	P2	P2	A9	1.00
DIRECTION 13	P2	P2	P3	1.00
DIRECTION 1	P3	P3	P2	1.00
DIRECTION 2	P3	P3	P6	1.00
DIRECTION 3	P3	P3	A5	1.00
DIRECTION 4	P3	P3	A9	1.00
DIRECTION 5	P3	P3	B5	1.00
DIRECTION 6	P3	P3	B9	1.00

DIRECTION	7	P3	P3	C5	1.00
DIRECTION	8	P3	P3	C9	1.00
DIRECTION	9	P3	P3	P4	1.00
DIRECTION	1	P4	P4	P3	1.00
DIRECTION	2	P4	P4	C9	1.00
DIRECTION	3	P4	P4	B9	1.00
DIRECTION	4	P4	P4	A9	1.00
DIRECTION	5	P4	P4	P2	1.00
DIRECTION	6	P4	P4	C5	1.00
DIRECTION	7	P4	P4	B5	1.00
DIRECTION	8	P4	P4	A5	1.00
DIRECTION	9	P4	P4	P6	1.00
DIRECTION	10	P4	P4	A2	1.00
DIRECTION	11	P4	P4	B2	1.00
DIRECTION	12	P4	P4	C2	1.00
DIRECTION	13	P4	P4	P1	1.00
DIRECTION	14	P4	P4	TOWER	1.00
DIRECTION	15	P4	P4	P5	1.00
DIRECTION	1	P5	P5	P4	1.00
DIRECTION	2	P5	P5	C2	1.00
DIRECTION	3	P5	P5	B2	1.00
DIRECTION	4	P5	P5	A2	1.00
DIRECTION	5	P5	P5	P2	1.00
DIRECTION	6	P5	P5	P6	1.00
DIRECTION	7	P5	P5	P1	1.00
DIRECTION	8	P5	P5	TOWER	1.00
AZIMUTH		P1	P1	P4	0.01

STATISTICS SUMMARY

NUMBER OF OBSERVATIONS		NUMBER OF UNKNOWNS	
DISTANCES	4	ZERO ERROR	0
DIRECTIONS	49	ORIENTATION	5
ANGLES	0		
AZIMUTHS	1		
COORDINATES	0	COORDINATES	30
TOTALS	54		35

THE NUMBER OF DEGREES OF FREEDOM IS 19

STATION 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484

STATION	SEMI-MAJOR AXIS	SEMI-MINOR AXIS	AZIMUTH OF SEMI-MAJOR AXIS	AREA OF ELLIPSE
P2	0.0054	0.0036	273 58 12	0.61235D-04
P3	0.0082	0.0039	71 2 29	0.99966D-04
P4	0.0075	0.0000	31 27 56	0.10258D-05
P5	0.0060	0.0022	14 42 51	0.42343D-04
P6	0.0042	0.0019	71 29 53	0.24896D-04
TOWER	0.0049	0.0014	352 1 17	0.20983D-04
A2	0.0051	0.0034	15 54 13	0.54215D-04
A5	0.0054	0.0033	42 35 18	0.55385D-04
A9	0.0060	0.0033	55 1 40	0.62581D-04
B2	0.0055	0.0023	32 59 5	0.40327D-04
B5	0.0062	0.0032	33 27 31	0.61388D-04
B9	0.0065	0.0039	42 32 42	0.79230D-04
C2	0.0062	0.0014	33 7 4	0.27874D-04
C5	0.0072	0.0033	24 59 47	0.74979D-04
C9	0.0071	0.0049	30 29 38	0.10897D-03

TOTAL AREA OF STATION ELLIPSES = 0.81540D-03

RELATIVE 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484

FROM	TO	SEMI-MAJOR	SEMI-MINOR	AZIMUTH MAJOR	DISTANCE	PRECISION	STD.DEV. ADJ.DISTANCE	STD.DEV. ADJ.AZIMUTH
P2	P3	0.0051	0.0029	51 34 36	200.8379	1: 39511	0.0021	1.24
P2	P4	0.0073	0.0035	356 4 49	369.1131	1: 50637	0.0030	0.80
P2	P5	0.0073	0.0045	326 25 10	360.3529	1: 49438	0.0030	1.05
P2	P6	0.0041	0.0020	312 43 50	121.3948	1: 29302	0.0017	1.42
P2	TOWER	0.0065	0.0054	340 11 6	271.0144	1: 41629	0.0025	1.82
P2	A2	0.0056	0.0030	336 53 54	190.8260	1: 34012	0.0023	1.34
P2	A5	0.0047	0.0027	347 24 2	167.9815	1: 35931	0.0019	1.34
P2	A9	0.0043	0.0027	5 5 47	163.5673	1: 38320	0.0017	1.40
P2	B2	0.0055	0.0032	344 54 34	236.9899	1: 43049	0.0022	1.14
P2	B5	0.0059	0.0030	352 27 34	220.1420	1: 37598	0.0024	1.16
P2	B9	0.0057	0.0032	355 37 26	212.9515	1: 37674	0.0023	1.33
P2	C2	0.0060	0.0034	350 17 12	283.3995	1: 47318	0.0024	1.00
P2	C5	0.0072	0.0032	354 38 57	265.3561	1: 36604	0.0030	1.01
P2	C9	0.0070	0.0037	349 17 1	255.0991	1: 36405	0.0027	1.40
P3	P4	0.0065	0.0038	328 19 12	319.2424	1: 49273	0.0026	1.02
P3	P5	0.0081	0.0053	293 38 56	402.5787	1: 49594	0.0033	1.12
P3	P6	0.0058	0.0038	82 33 45	245.7821	1: 42557	0.0024	1.29
P3	TOWER	0.0083	0.0068	74 23 19	398.2835	1: 47934	0.0033	1.49
P3	A2	0.0060	0.0054	311 43 30	262.0620	1: 43517	0.0024	1.79
P3	A5	0.0049	0.0037	290 49 25	202.1014	1: 41542	0.0020	1.56
P3	A9	0.0039	0.0027	290 25 20	145.2863	1: 36985	0.0016	1.56
P3	B2	0.0057	0.0048	308 45 47	261.1150	1: 45822	0.0023	1.56
P3	B5	0.0055	0.0038	319 4 20	216.7572	1: 39548	0.0022	1.57
P3	B9	0.0050	0.0030	316 40 51	169.8202	1: 33722	0.0020	1.53
P3	C2	0.0058	0.0045	315 48 56	278.0625	1: 47703	0.0024	1.38
P3	C5	0.0067	0.0039	334 7 57	237.5708	1: 35455	0.0026	1.56
P3	C9	0.0064	0.0032	326 6 23	191.1469	1: 29679	0.0026	1.44
P4	P5	0.0044	0.0018	63 34 43	170.6388	1: 39116	0.0018	0.91
P4	P6	0.0056	0.0026	12 0 56	281.0009	1: 50535	0.0023	0.78
P4	TOWER	0.0073	0.0033	28 28 27	306.1020	1: 41989	0.0029	1.02
P4	A2	0.0055	0.0027	2 43 0	210.1371	1: 38083	0.0022	1.22
P4	A5	0.0050	0.0023	357 17 21	202.8088	1: 40818	0.0020	0.97
P4	A9	0.0050	0.0024	346 40 2	214.3067	1: 43228	0.0020	0.92
P4	B2	0.0039	0.0020	9 43 59	147.9639	1: 37629	0.0016	1.17
P4	B5	0.0047	0.0019	355 37 38	149.3086	1: 31491	0.0019	1.09
P4	B9	0.0050	0.0020	342 18 21	165.8130	1: 32991	0.0021	1.02
P4	C2	0.0029	0.0014	20 19 19	96.5092	1: 33215	0.0012	1.18
P4	C5	0.0053	0.0014	354 13 55	103.7794	1: 19553	0.0022	1.16
P4	C9	0.0058	0.0017	335 44 56	130.8117	1: 22633	0.0024	1.11
P5	P6	0.0053	0.0034	338 46 5	241.4552	1: 45913	0.0021	1.18
P5	TOWER	0.0060	0.0024	13 40 4	173.5491	1: 29166	0.0024	1.18
P5	A2	0.0052	0.0027	329 46 0	170.0210	1: 32983	0.0021	1.35
P5	A5	0.0052	0.0039	327 31 40	212.2984	1: 41219	0.0021	1.58
P5	A9	0.0057	0.0042	308 21 30	260.5980	1: 45856	0.0023	1.36
P5	B2	0.0038	0.0023	302 42 44	142.5802	1: 37133	0.0016	1.37
P5	B5	0.0050	0.0041	337 45 48	185.8232	1: 37497	0.0019	2.02
P5	B9	0.0057	0.0044	315 0 53	234.4777	1: 41398	0.0023	1.64
P5	C2	0.0035	0.0020	270 1 7	131.2793	1: 37450	0.0014	1.37
P5	C5	0.0056	0.0042	354 23 46	174.5560	1: 31216	0.0018	2.62
P5	C9	0.0063	0.0047	322 51 5	228.2247	1: 35945	0.0024	1.97
P6	TOWER	0.0053	0.0042	9 15 50	160.0699	1: 30269	0.0017	2.77
P6	A2	0.0047	0.0022	341 5 24	76.7414	1: 16241	0.0019	2.55

P6	A5	0.0038	0.0026	347	22	17	88.4541	1:	23489	0.0013	3.15
P6	A9	0.0035	0.0034	355	49	39	127.8180	1:	36333	0.0014	2.30
P6	B2	0.0041	0.0024	353	7	44	134.7980	1:	32580	0.0017	1.56
P6	B5	0.0047	0.0027	0	6	45	138.3957	1:	29737	0.0018	1.93
P6	B9	0.0046	0.0034	357	13	2	159.5109	1:	34303	0.0017	2.17
P6	C2	0.0044	0.0024	4	35	40	186.2100	1:	42057	0.0018	1.10
P6	C5	0.0060	0.0028	1	44	28	183.4146	1:	30782	0.0023	1.51
P6	C9	0.0059	0.0038	349	21	29	196.9421	1:	33161	0.0020	2.18
TOWER	A2	0.0060	0.0038	3	44	34	143.6213	1:	23860	0.0016	3.48
TOWER	A5	0.0063	0.0045	16	7	3	203.5244	1:	32552	0.0020	2.50
TOWER	A9	0.0065	0.0053	28	36	23	260.8854	1:	40201	0.0023	2.00
TOWER	B2	0.0059	0.0036	21	0	23	183.3184	1:	31273	0.0020	2.19
TOWER	B5	0.0068	0.0044	18	7	16	222.1546	1:	32692	0.0022	2.29
TOWER	B9	0.0070	0.0054	20	34	17	267.9666	1:	38357	0.0024	2.05
TOWER	C2	0.0063	0.0032	26	37	13	220.0437	1:	34874	0.0024	1.56
TOWER	C5	0.0077	0.0045	14	47	13	247.5546	1:	32351	0.0025	2.17
TOWER	C9	0.0077	0.0059	9	45	44	289.0069	1:	37648	0.0026	2.11
A2	A5	0.0053	0.0025	347	6	10	61.0660	1:	11579	0.0012	7.03
A2	A9	0.0053	0.0032	345	37	24	119.2720	1:	22579	0.0014	3.60
A2	B2	0.0043	0.0021	343	48	46	62.2274	1:	14503	0.0015	4.20
A2	B5	0.0057	0.0026	352	19	3	84.1052	1:	14649	0.0014	5.23
A2	B9	0.0060	0.0033	347	32	0	125.2262	1:	20944	0.0013	4.01
A2	C2	0.0044	0.0023	352	22	30	113.7200	1:	25657	0.0017	2.10
A2	C5	0.0067	0.0027	355	0	53	121.3948	1:	18060	0.0021	3.50
A2	C9	0.0070	0.0035	344	32	39	151.3692	1:	21582	0.0016	3.78
A5	A9	0.0034	0.0024	339	28	0	58.2204	1:	17068	0.0011	4.67
A5	B2	0.0045	0.0023	350	45	2	73.1120	1:	16250	0.0017	3.13
A5	B5	0.0043	0.0021	349	27	59	53.8391	1:	12552	0.0017	3.83
A5	B9	0.0042	0.0025	342	59	47	72.7820	1:	17260	0.0011	4.68
A5	C2	0.0044	0.0023	354	27	48	115.6378	1:	26088	0.0018	1.69
A5	C5	0.0054	0.0021	352	59	46	100.1753	1:	18470	0.0021	2.13
A5	C9	0.0055	0.0027	340	28	41	108.5288	1:	19585	0.0015	3.81
A9	B2	0.0045	0.0028	345	39	18	117.9332	1:	26133	0.0016	2.59
A9	B5	0.0041	0.0022	343	1	27	77.8360	1:	18883	0.0016	2.85
A9	B9	0.0038	0.0021	337	0	54	50.2000	1:	13185	0.0015	4.05
A9	C2	0.0044	0.0027	346	4	50	145.3818	1:	32718	0.0017	1.72
A9	C5	0.0054	0.0022	348	6	35	113.4053	1:	21127	0.0022	1.74
A9	C9	0.0053	0.0022	336	54	26	91.8619	1:	17357	0.0019	2.95
B2	B5	0.0048	0.0022	354	42	52	46.5972	1:	9631	0.0010	8.46
B2	B9	0.0051	0.0028	346	6	23	97.7287	1:	19106	0.0014	4.13
B2	C2	0.0028	0.0019	357	5	26	51.7584	1:	18765	0.0011	3.22
B2	C5	0.0058	0.0022	356	11	39	64.7389	1:	11147	0.0014	6.66
B2	C9	0.0062	0.0030	341	42	31	107.6636	1:	17443	0.0012	4.81
B5	B9	0.0045	0.0022	341	47	4	51.1344	1:	11296	0.0012	6.77
B5	C2	0.0046	0.0021	356	33	21	68.1954	1:	14887	0.0017	3.39
B5	C5	0.0053	0.0018	351	41	21	46.3441	1:	8664	0.0021	4.36
B5	C9	0.0056	0.0024	338	49	12	67.5592	1:	11979	0.0010	6.99
B9	C2	0.0049	0.0026	344	51	46	108.2977	1:	22227	0.0017	2.74
B9	C5	0.0054	0.0020	345	36	27	69.4894	1:	12790	0.0021	3.46
B9	C9	0.0055	0.0019	335	7	59	42.2147	1:	7707	0.0018	7.31
C2	C5	0.0054	0.0019	356	46	43	43.4181	1:	7971	0.0011	9.92
C2	C9	0.0059	0.0026	339	32	52	96.9524	1:	16548	0.0017	4.30
C5	C9	0.0062	0.0022	341	25	12	53.5811	1:	8577	0.0016	8.41

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*                                                                                       *
*          BALL MOUNTAIN DAM, VERMONT  0.5; 0.005,5.0                                   *
*                                                                                       *
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                                   THU, NOV. 28, 1985    17:32:08

                                  O P T I O N S   I N   E F F E C T
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          PREANALYSIS OR ADJUSTMENT ........................................  PREANALYSIS

          FIXED STATIONS                  WEIGHTED STATIONS                 BLAHA STATIONS
             P1

          CONVENTIONAL LINEAR UNIT .............................................  METRE
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INITIAL APPROXIMATE COORDINATES

FREE STATIONS:

STATION	X (E)	Y (N)
P2	304.8000	21.3000
P3	474.0000	129.5000
P4	289.6000	390.1000
P5	128.0000	335.3000
P6	228.6000	115.8000
TOWER	77.7000	169.2000
A2	219.5000	192.0000
A5	280.4000	187.5000
A9	338.3000	181.4000
B2	242.3000	249.9000
B5	288.0000	240.8000
B9	338.3000	231.6000
C2	254.5000	300.2000
C5	295.7000	286.5000
C9	347.5000	272.8000

FIXED STATIONS:

STATION	X (E)	Y (N)
P1	97.5000	76.2000

SUMMARY OF INPUT OBSERVATIONS AND THEIR STANDARD DEVIATIONS:

	AT	FROM	TO	STD.DEV
DISTANCE	P4	P4	P3	0.005
DISTANCE	P4	P4	P2	0.005
DISTANCE	P4	P4	P6	0.005
DISTANCE	P4	P4	P1	0.005
DIRECTION 1	P1	P1	TOWER	0.50
DIRECTION 2	P1	P1	P5	0.50
DIRECTION 3	P1	P1	P4	0.50
DIRECTION 4	P1	P1	P6	0.50
DIRECTION 1	P2	P2	P6	0.50
DIRECTION 2	P2	P2	P5	0.50
DIRECTION 3	P2	P2	A2	0.50
DIRECTION 4	P2	P2	B2	0.50
DIRECTION 5	P2	P2	C2	0.50
DIRECTION 6	P2	P2	A5	0.50
DIRECTION 7	P2	P2	B5	0.50
DIRECTION 8	P2	P2	C5	0.50
DIRECTION 9	P2	P2	P4	0.50
DIRECTION 10	P2	P2	B9	0.50
DIRECTION 11	P2	P2	C9	0.50
DIRECTION 12	P2	P2	A9	0.50
DIRECTION 13	P2	P2	P3	0.50
DIRECTION 1	P3	P3	P2	0.50
DIRECTION 2	P3	P3	P6	0.50
DIRECTION 3	P3	P3	A5	0.50
DIRECTION 4	P3	P3	A9	0.50
DIRECTION 5	P3	P3	B5	0.50
DIRECTION 6	P3	P3	B9	0.50

DIRECTION 7	P3	P3	C5	0.50
DIRECTION 8	P3	P3	C9	0.50
DIRECTION 9	P3	P3	P4	0.50
DIRECTION 1	P4	P4	P3	0.50
DIRECTION 2	P4	P4	C9	0.50
DIRECTION 3	P4	P4	B9	0.50
DIRECTION 4	P4	P4	A9	0.50
DIRECTION 5	P4	P4	P2	0.50
DIRECTION 6	P4	P4	C5	0.50
DIRECTION 7	P4	P4	B5	0.50
DIRECTION 8	P4	P4	A5	0.50
DIRECTION 9	P4	P4	P6	0.50
DIRECTION 10	P4	P4	A2	0.50
DIRECTION 11	P4	P4	B2	0.50
DIRECTION 12	P4	P4	C2	0.50
DIRECTION 13	P4	P4	P1	0.50
DIRECTION 14	P4	P4	TOWER	0.50
DIRECTION 15	P4	P4	P5	0.50
DIRECTION 1	P5	P5	P4	0.50
DIRECTION 2	P5	P5	C2	0.50
DIRECTION 3	P5	P5	B2	0.50
DIRECTION 4	P5	P5	A2	0.50
DIRECTION 5	P5	P5	P2	0.50
DIRECTION 6	P5	P5	P6	0.50
DIRECTION 7	P5	P5	P1	0.50
DIRECTION 8	P5	P5	TOWER	0.50
AZIMUTH	P1	P1	P4	0.01

STATISTICS SUMMARY

NUMBER OF OBSERVATIONS		NUMBER OF UNKNOWNS	
DISTANCES	4	ZERO ERROR	0
DIRECTIONS	49	ORIENTATION	5
ANGLES	0		
AZIMUTHS	1		
COORDINATES	0	COORDINATES	30
TOTALS	54		35

THE NUMBER OF DEGREES OF FREEDOM IS 19

STATION 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484

STATION	SEMI-MAJOR AXIS	SEMI-MINOR AXIS	AZIMUTH OF SEMI-MAJOR AXIS	AREA OF ELLIPSE
P2	0.0045	0.0019	282 9 56	0.26163D-04
P3	0.0075	0.0021	79 12 28	0.48705D-04
P4	0.0072	0.0000	31 27 56	0.98615D-06
P5	0.0053	0.0012	9 5 21	0.19342D-04
P6	0.0031	0.0009	72 22 28	0.92318D-05
TOWER	0.0029	0.0007	350 47 2	0.62882D-05
A2	0.0037	0.0019	37 35 3	0.21945D-04
A5	0.0044	0.0017	54 23 36	0.24096D-04
A9	0.0053	0.0017	63 29 9	0.28765D-04
B2	0.0047	0.0012	37 44 59	0.17546D-04
B5	0.0052	0.0017	44 42 59	0.27653D-04
B9	0.0057	0.0020	53 49 54	0.36817D-04
C2	0.0055	0.0007	34 26 18	0.12516D-04
C5	0.0059	0.0019	37 50 38	0.34857D-04
C9	0.0063	0.0026	47 49 30	0.51442D-04

TOTAL AREA OF STATION ELLIPSES = 0.36635D-03

RELATIVE 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484

FROM	TO	SEMI-MAJOR	SEMI-MINOR	AZIMUTH MAJOR	DISTANCE	PRECISION	STD.DEV. ADJ.DISTANCE	STD.DEV. ADJ.AZIMUTH
P2	P3	0.0042	0.0015	55 45 33	200.8379	1: 47831	0.0017	0.62
P2	P4	0.0072	0.0018	357 18 5	369.1131	1: 51623	0.0029	0.40
P2	P5	0.0070	0.0022	329 50 20	360.3529	1: 51316	0.0029	0.52
P2	P6	0.0029	0.0010	317 28 20	121.3948	1: 41871	0.0012	0.71
P2	TOWER	0.0055	0.0029	307 19 9	271.0144	1: 49523	0.0022	0.92
P2	A2	0.0042	0.0015	334 41 17	190.8260	1: 44993	0.0017	0.67
P2	A5	0.0036	0.0013	350 16 48	167.9815	1: 46073	0.0015	0.67
P2	A9	0.0035	0.0014	10 0 6	163.5673	1: 47294	0.0014	0.70
P2	B2	0.0048	0.0016	344 45 30	236.9899	1: 49210	0.0020	0.57
P2	B5	0.0047	0.0015	354 36 29	220.1420	1: 46906	0.0019	0.58
P2	B9	0.0045	0.0017	5 2 18	212.9515	1: 47173	0.0018	0.67
P2	C2	0.0056	0.0017	349 52 52	283.3995	1: 50667	0.0023	0.50
P2	C5	0.0057	0.0016	356 49 56	265.3561	1: 46412	0.0023	0.51
P2	C9	0.0054	0.0020	3 4 40	255.0991	1: 46878	0.0022	0.70
P3	P4	0.0062	0.0019	325 25 53	319.2424	1: 51246	0.0025	0.51
P3	P5	0.0078	0.0027	299 32 17	402.5787	1: 51392	0.0032	0.56
P3	P6	0.0050	0.0019	85 56 47	245.7821	1: 49048	0.0020	0.65
P3	TOWER	0.0078	0.0035	273 27 51	398.2835	1: 51145	0.0032	0.75
P3	A2	0.0053	0.0028	285 51 54	262.0620	1: 49704	0.0022	0.90
P3	A5	0.0042	0.0019	287 26 9	202.1014	1: 48655	0.0017	0.78
P3	A9	0.0031	0.0013	290 49 44	145.2863	1: 46598	0.0013	0.78
P3	B2	0.0052	0.0024	298 44 17	261.1150	1: 50260	0.0021	0.78
P3	B5	0.0045	0.0020	304 56 9	216.7572	1: 48130	0.0018	0.79
P3	B9	0.0038	0.0015	310 15 25	169.8202	1: 44940	0.0015	0.77
P3	C2	0.0055	0.0023	308 59 1	278.0625	1: 50822	0.0022	0.69
P3	C5	0.0051	0.0021	318 35 20	237.5708	1: 46456	0.0021	0.78
P3	C9	0.0045	0.0016	321 52 43	191.1469	1: 42265	0.0018	0.72
P4	P5	0.0036	0.0009	68 44 18	170.6388	1: 47701	0.0015	0.45
P4	P6	0.0054	0.0013	12 24 54	281.0009	1: 51598	0.0022	0.39
P4	TOWER	0.0062	0.0018	39 25 47	306.1020	1: 49123	0.0025	0.51
P4	A2	0.0044	0.0015	14 11 4	210.1371	1: 47538	0.0018	0.61
P4	A5	0.0042	0.0012	1 0 58	202.8088	1: 48389	0.0017	0.49
P4	A9	0.0043	0.0012	346 48 13	214.3067	1: 49285	0.0018	0.46
P4	B2	0.0031	0.0010	15 47 27	147.9639	1: 47031	0.0013	0.59
P4	B5	0.0034	0.0010	358 27 20	149.3086	1: 43484	0.0014	0.55
P4	B9	0.0037	0.0010	342 39 39	165.8130	1: 44388	0.0015	0.51
P4	C2	0.0022	0.0007	20 56 9	96.5092	1: 44531	0.0009	0.59
P4	C5	0.0032	0.0007	354 59 11	103.7794	1: 32768	0.0013	0.58
P4	C9	0.0036	0.0009	334 57 59	130.8117	1: 36138	0.0015	0.56
P5	P6	0.0048	0.0017	336 2 17	241.4552	1: 50228	0.0020	0.59
P5	TOWER	0.0042	0.0012	15 22 58	173.5491	1: 41775	0.0017	0.59
P5	A2	0.0038	0.0014	328 18 10	170.0210	1: 44396	0.0016	0.68
P5	A5	0.0044	0.0020	316 33 6	212.2984	1: 48678	0.0018	0.79
P5	A9	0.0052	0.0021	306 33 12	260.5980	1: 50219	0.0021	0.68
P5	B2	0.0031	0.0012	305 34 16	142.6802	1: 46693	0.0012	0.69
P5	B5	0.0039	0.0022	305 37 19	185.8232	1: 47784	0.0016	1.01
P5	B9	0.0048	0.0023	299 18 51	234.4777	1: 48878	0.0020	0.82
P5	C2	0.0028	0.0010	280 51 57	131.2793	1: 47144	0.0011	0.68
P5	C5	0.0037	0.0027	296 40 34	174.6560	1: 47312	0.0015	1.31
P5	C9	0.0048	0.0026	293 50 30	228.2247	1: 47418	0.0020	0.98
P6	TOWER	0.0034	0.0026	294 55 4	160.0699	1: 47050	0.0014	1.39
P6	A2	0.0027	0.0011	344 16 39	76.7414	1: 28647	0.0011	1.28

P6	A5	0.0022	0.0015	13	47	54	88.4541	1:	39327	0.0009	1.58
P6	A9	0.0027	0.0018	57	39	36	127.8180	1:	46947	0.0011	1.16
P6	B2	0.0030	0.0012	1	13	35	134.7980	1:	44338	0.0012	0.78
P6	B5	0.0032	0.0015	15	24	19	138.3957	1:	43053	0.0013	0.97
P6	B9	0.0034	0.0020	33	42	26	159.5109	1:	47223	0.0014	1.09
P6	C2	0.0038	0.0012	7	4	33	186.2100	1:	48857	0.0016	0.55
P6	C5	0.0042	0.0015	13	4	51	183.4146	1:	43533	0.0017	0.76
P6	C9	0.0042	0.0024	23	46	46	196.9421	1:	47257	0.0017	1.09
TOWER	A2	0.0032	0.0028	44	59	30	143.6213	1:	44323	0.0013	1.74
TOWER	A5	0.0042	0.0030	73	48	36	203.5244	1:	48591	0.0017	1.26
TOWER	A9	0.0052	0.0031	82	10	15	260.8854	1:	50152	0.0021	1.01
TOWER	B2	0.0040	0.0022	49	17	52	183.3184	1:	45594	0.0016	1.10
TOWER	B5	0.0047	0.0029	56	49	39	222.1546	1:	47532	0.0019	1.15
TOWER	B9	0.0054	0.0032	69	15	55	267.9666	1:	49710	0.0022	1.03
TOWER	C2	0.0047	0.0019	44	15	8	220.0437	1:	46450	0.0019	0.78
TOWER	C5	0.0053	0.0030	46	25	3	247.5546	1:	46898	0.0021	1.08
TOWER	C9	0.0058	0.0036	61	28	18	289.0069	1:	49705	0.0024	1.06
A2	A5	0.0027	0.0016	343	28	16	61.0660	1:	22967	0.0007	3.52
A2	A9	0.0029	0.0023	315	1	32	119.2720	1:	41738	0.0011	1.80
A2	B2	0.0023	0.0012	351	31	25	62.2274	1:	26913	0.0009	2.10
A2	B5	0.0030	0.0018	0	36	43	84.1052	1:	28370	0.0009	2.62
A2	B9	0.0030	0.0026	359	27	1	125.2262	1:	41537	0.0011	2.00
A2	C2	0.0029	0.0013	5	10	37	113.7200	1:	39830	0.0011	1.05
A2	C5	0.0037	0.0018	6	27	6	121.3948	1:	32635	0.0013	1.75
A2	C9	0.0037	0.0029	5	41	7	151.3692	1:	41172	0.0013	1.89
A5	A9	0.0018	0.0014	320	16	14	58.2204	1:	32395	0.0007	2.34
A5	B2	0.0025	0.0012	344	41	18	73.1120	1:	28909	0.0010	1.56
A5	B5	0.0023	0.0011	352	51	31	53.8391	1:	23303	0.0009	1.91
A5	B9	0.0022	0.0016	356	52	31	72.7820	1:	33429	0.0007	2.34
A5	C2	0.0029	0.0011	350	42	57	115.6378	1:	39434	0.0012	0.84
A5	C5	0.0032	0.0011	357	48	31	100.1753	1:	31673	0.0013	1.06
A5	C9	0.0030	0.0019	357	24	15	108.5288	1:	36057	0.0011	1.90
A9	B2	0.0029	0.0017	323	0	33	117.9332	1:	41290	0.0011	1.30
A9	B5	0.0024	0.0012	334	48	47	77.8360	1:	32426	0.0010	1.42
A9	B9	0.0021	0.0011	341	42	23	50.2000	1:	24384	0.0008	2.02
A9	C2	0.0032	0.0014	332	5	21	145.3818	1:	44782	0.0013	0.86
A9	C5	0.0033	0.0011	344	20	10	113.4053	1:	34633	0.0013	0.87
A9	C9	0.0030	0.0013	344	48	51	91.8619	1:	30722	0.0012	1.48
B2	B5	0.0024	0.0013	352	25	23	46.5972	1:	19168	0.0006	4.23
B2	B9	0.0027	0.0020	328	37	20	97.7287	1:	36097	0.0009	2.07
B2	C2	0.0016	0.0010	4	5	36	51.7584	1:	32034	0.0007	1.61
B2	C5	0.0030	0.0014	0	31	33	64.7389	1:	21856	0.0008	3.33
B2	C9	0.0031	0.0023	337	8	11	107.5636	1:	34761	0.0010	2.41
B5	B9	0.0023	0.0013	336	51	52	51.1344	1:	22175	0.0007	3.39
B5	C2	0.0025	0.0011	350	45	11	68.1954	1:	27079	0.0010	1.70
B5	C5	0.0028	0.0009	353	9	20	46.3441	1:	16701	0.0011	2.18
B5	C9	0.0028	0.0016	340	29	17	67.5592	1:	23921	0.0007	3.49
B9	C2	0.0029	0.0015	329	53	27	108.2977	1:	37126	0.0011	1.37
B9	C5	0.0029	0.0011	341	46	26	69.4894	1:	23763	0.0011	1.73
B9	C9	0.0028	0.0011	337	10	26	42.2147	1:	15096	0.0010	3.66
C2	C5	0.0027	0.0012	355	6	6	43.4181	1:	15860	0.0006	4.96
C2	C9	0.0031	0.0018	328	23	14	96.9524	1:	31014	0.0011	2.15
C5	C9	0.0032	0.0013	338	53	17	53.5811	1:	16927	0.0009	4.21

3

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*****************************************************************************************
*                                                                                       *
*          BALL MOUNTAIN DAM, VERMONT  0.5; 0.003,2.0                                   *
*                                                                                       *
*****************************************************************************************
                                   THU, NOV. 28, 1985    13:13:24

                                 O P T I O N S   I N   E F F E C T
                                 ---------------------------------

          PREANALYSIS OR ADJUSTMENT ........................................ PREANALYSIS

          FIXED STATIONS                  WEIGHTED STATIONS                 BLAHA STATIONS
             P1

          CONVENTIONAL LINEAR UNIT ................................................ METRE
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INITIAL APPROXIMATE COORDINATES

FREE STATIONS:

STATION	X (E)	Y (N)
P2	304.8000	21.3000
P3	474.0000	129.5000
P4	289.6000	390.1000
P5	128.0000	335.3000
P6	228.6000	115.8000
TOWER	77.7000	169.2000
A2	219.5000	192.0000
A5	280.4000	187.5000
A9	338.3000	181.4000
B2	242.3000	249.9000
B5	288.0000	240.8000
B9	338.3000	231.6000
C2	254.5000	300.2000
C5	295.7000	286.5000
C9	347.5000	272.8000

FIXED STATIONS:

STATION	X (E)	Y (N)
P1	97.5000	76.2000

SUMMARY OF INPUT OBSERVATIONS AND THEIR STANDARD DEVIATIONS:

	AT	FROM	TO	STD.DEV
DISTANCE	P4	P4	P3	0.003
DISTANCE	P4	P4	P2	0.003
DISTANCE	P4	P4	P6	0.003
DISTANCE	P4	P4	P1	0.003
DIRECTION 1	P1	P1	TOWER	0.50
DIRECTION 2	P1	P1	P5	0.50
DIRECTION 3	P1	P1	P4	0.50
DIRECTION 4	P1	P1	P6	0.50
DIRECTION 1	P2	P2	P6	0.50
DIRECTION 2	P2	P2	P5	0.50
DIRECTION 3	P2	P2	A2	0.50
DIRECTION 4	P2	P2	B2	0.50
DIRECTION 5	P2	P2	C2	0.50
DIRECTION 6	P2	P2	A5	0.50
DIRECTION 7	P2	P2	B5	0.50
DIRECTION 8	P2	P2	C5	0.50
DIRECTION 9	P2	P2	P4	0.50
DIRECTION 10	P2	P2	B9	0.50
DIRECTION 11	P2	P2	C9	0.50
DIRECTION 12	P2	P2	A9	0.50
DIRECTION 13	P2	P2	P3	0.50
DIRECTION 1	P3	P3	P2	0.50
DIRECTION 2	P3	P3	P6	0.50
DIRECTION 3	P3	P3	A5	0.50
DIRECTION 4	P3	P3	A9	0.50
DIRECTION 5	P3	P3	B5	0.50
DIRECTION 6	P3	P3	B9	0.50

DIRECTION 7	P3	P3	C5	0.50
DIRECTION 8	P3	P3	C9	0.50
DIRECTION 9	P3	P3	P4	0.50
DIRECTION 1	P4	P4	P3	0.50
DIRECTION 2	P4	P4	C9	0.50
DIRECTION 3	P4	P4	B9	0.50
DIRECTION 4	P4	P4	A9	0.50
DIRECTION 5	P4	P4	P2	0.50
DIRECTION 6	P4	P4	C5	0.50
DIRECTION 7	P4	P4	B5	0.50
DIRECTION 8	P4	P4	A5	0.50
DIRECTION 9	P4	P4	P6	0.50
DIRECTION 10	P4	P4	A2	0.50
DIRECTION 11	P4	P4	B2	0.50
DIRECTION 12	P4	P4	C2	0.50
DIRECTION 13	P4	P4	P1	0.50
DIRECTION 14	P4	P4	TOWER	0.50
DIRECTION 15	P4	P4	P5	0.50
DIRECTION 1	P5	P5	P4	0.50
DIRECTION 2	P5	P5	C2	0.50
DIRECTION 3	P5	P5	B2	0.50
DIRECTION 4	P5	P5	A2	0.50
DIRECTION 5	P5	P5	P2	0.50
DIRECTION 6	P5	P5	P6	0.50
DIRECTION 7	P5	P5	P1	0.50
DIRECTION 8	P5	P5	TOWER	0.50
AZIMUTH	P1	P1	P4	0.01

STATISTICS SUMMARY

NUMBER OF OBSERVATIONS		NUMBER OF UNKNOWNS	
DISTANCES	4	ZERO ERROR	0
DIRECTIONS	49	ORIENTATION	5
ANGLES	0		
AZIMUTHS	1		
COORDINATES	0	COORDINATES	30
TOTALS	54		35

THE NUMBER OF DEGREES OF FREEDOM IS 19

STATION 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484

STATION	SEMI-MAJOR AXIS	SEMI-MINOR AXIS	AZIMUTH OF SEMI-MAJOR AXIS	AREA OF ELLIPSE
P2	0.0030	0.0018	276 47 40	0.16984D-04
P3	0.0046	0.0020	73 50 45	0.28852D-04
P4	0.0043	0.0000	31 27 56	0.58939D-06
P5	0.0034	0.0011	12 58 25	0.11970D-04
P6	0.0023	0.0009	71 40 27	0.66630D-05
TOWER	0.0025	0.0007	351 49 20	0.53810D-05
A2	0.0027	0.0018	21 48 0	0.14811D-04
A5	0.0029	0.0017	46 24 57	0.15430D-04
A9	0.0034	0.0017	57 53 30	0.17723D-04
B2	0.0030	0.0012	34 26 39	0.11236D-04
B5	0.0034	0.0016	36 57 27	0.17277D-04
B9	0.0036	0.0020	46 37 38	0.22512D-04
C2	0.0035	0.0007	33 31 7	0.78418D-05
C5	0.0039	0.0017	28 47 27	0.21308D-04
C9	0.0040	0.0025	37 20 21	0.31119D-04

TOTAL AREA OF STATION ELLIPSES = 0.22970D-03

RELATIVE 95.000 % CONFIDENCE ELLIPSES (METRES)

FACTOR USED FOR OBTAINING THESE ELLIPSES FROM STANDARD ELLIPSES: (VARIANCE FACTOR KNOWN) = 2.4484

FROM	TO	SEMI-MAJOR	SEMI-MINOR	AZIMUTH MAJOR	DISTANCE	PRECISION	STD.DEV. ADJ.DISTANCE	STD.DEV. ADJ.AZIMUTH
P2	P3	0.0028	0.0015	52 56 6	200.8379	1: 72013	0.0011	0.62
P2	P4	0.0042	0.0018	356 33 23	369.1131	1: 87551	0.0017	0.40
P2	P5	0.0042	0.0022	327 51 59	360.3529	1: 86029	0.0017	0.52
P2	P6	0.0022	0.0010	313 52 37	121.3948	1: 55487	0.0009	0.71
P2	TOWER	0.0035	0.0028	324 58 34	271.0144	1: 76730	0.0014	0.91
P2	A2	0.0030	0.0015	336 18 21	190.8260	1: 63353	0.0012	0.67
P2	A5	0.0025	0.0013	348 15 10	167.9815	1: 66447	0.0010	0.67
P2	A9	0.0023	0.0014	6 43 31	163.5673	1: 70209	0.0009	0.70
P2	B2	0.0031	0.0016	344 51 58	236.9899	1: 77157	0.0013	0.57
P2	B5	0.0032	0.0015	353 5 57	220.1420	1: 69043	0.0013	0.58
P2	B9	0.0031	0.0016	358 28 22	212.9515	1: 69390	0.0012	0.67
P2	C2	0.0034	0.0017	350 8 10	283.3995	1: 83141	0.0014	0.50
P2	C5	0.0039	0.0016	355 15 8	265.3561	1: 67491	0.0016	0.51
P2	C9	0.0038	0.0019	353 5 18	255.0991	1: 67679	0.0015	0.70
P3	P4	0.0037	0.0019	327 9 35	319.2424	1: 85754	0.0015	0.51
P3	P5	0.0047	0.0027	296 14 50	402.5787	1: 86299	0.0019	0.56
P3	P6	0.0032	0.0019	83 53 55	245.7821	1: 76486	0.0013	0.65
P3	TOWER	0.0047	0.0035	84 40 31	398.2835	1: 84698	0.0019	0.75
P3	A2	0.0033	0.0028	295 47 19	262.0620	1: 78617	0.0014	0.90
P3	A5	0.0027	0.0019	289 24 2	202.1014	1: 75003	0.0011	0.78
P3	A9	0.0021	0.0013	290 35 41	145.2863	1: 68078	0.0009	0.78
P3	B2	0.0032	0.0024	303 21 8	261.1150	1: 81239	0.0013	0.78
P3	B5	0.0030	0.0020	313 59 34	216.7572	1: 72422	0.0012	0.78
P3	B9	0.0027	0.0015	314 53 49	169.8202	1: 62971	0.0011	0.77
P3	C2	0.0033	0.0023	312 28 47	278.0625	1: 83737	0.0014	0.69
P3	C5	0.0036	0.0020	329 52 43	237.5708	1: 66210	0.0014	0.78
P3	C9	0.0034	0.0016	325 8 6	191.1469	1: 56213	0.0014	0.72
P4	P5	0.0024	0.0009	65 3 48	170.6388	1: 71461	0.0010	0.45
P4	P6	0.0032	0.0013	12 9 54	281.0009	1: 87412	0.0013	0.39
P4	TOWER	0.0040	0.0017	31 52 0	306.1020	1: 76013	0.0016	0.51
P4	A2	0.0030	0.0014	5 59 25	210.1371	1: 70174	0.0012	0.61
P4	A5	0.0027	0.0012	358 26 47	202.8088	1: 73960	0.0011	0.49
P4	A9	0.0028	0.0012	346 42 49	214.3067	1: 77422	0.0011	0.46
P4	B2	0.0021	0.0010	11 30 21	147.9639	1: 69198	0.0009	0.59
P4	B5	0.0025	0.0010	356 17 50	149.3086	1: 59252	0.0010	0.55
P4	B9	0.0027	0.0010	342 23 35	165.8130	1: 61696	0.0011	0.51
P4	C2	0.0016	0.0007	20 28 55	96.5092	1: 62074	0.0006	0.59
P4	C5	0.0027	0.0007	354 21 26	103.7794	1: 38158	0.0011	0.58
P4	C9	0.0030	0.0009	335 36 27	130.8117	1: 43809	0.0012	0.56
P5	P6	0.0030	0.0017	337 40 38	241.4552	1: 81222	0.0012	0.59
P5	TOWER	0.0031	0.0012	14 3 51	173.5491	1: 55279	0.0013	0.59
P5	A2	0.0028	0.0014	329 22 57	170.0210	1: 61701	0.0011	0.68
P5	A5	0.0028	0.0020	322 58 46	212.2984	1: 74763	0.0012	0.79
P5	A9	0.0032	0.0021	307 33 59	260.5980	1: 81165	0.0013	0.68
P5	B2	0.0021	0.0012	303 36 41	142.6802	1: 68343	0.0009	0.69
P5	B5	0.0026	0.0021	324 26 2	185.8232	1: 70279	0.0010	1.01
P5	B9	0.0031	0.0022	308 14 50	234.4777	1: 75252	0.0013	0.82
P5	C2	0.0019	0.0010	273 15 25	131.2793	1: 69122	0.0008	0.68
P5	C5	0.0028	0.0023	346 59 5	174.6560	1: 61708	0.0010	1.31
P5	C9	0.0034	0.0024	313 59 19	228.2247	1: 67885	0.0013	0.98
P6	TOWER	0.0027	0.0023	5 5 51	160.0699	1: 60317	0.0009	1.38
P6	A2	0.0024	0.0011	341 34 18	76.7414	1: 31940	0.0010	1.28

P6	A5	0.0019	0.0014	351	14	9	88.4541	1:	46131	0.0007	1.58
P6	A9	0.0019	0.0017	43	3	39	127.8180	1:	68893	0.0008	1.15
P6	B2	0.0022	0.0012	355	15	56	134.7980	1:	61154	0.0009	0.78
P6	B5	0.0024	0.0014	3	35	29	138.3957	1:	56737	0.0009	0.97
P6	B9	0.0024	0.0018	6	40	36	159.5109	1:	65757	0.0009	1.09
P6	C2	0.0025	0.0012	5	25	16	186.2100	1:	75742	0.0010	0.55
P6	C5	0.0031	0.0014	4	18	10	183.4146	1:	58365	0.0012	0.76
P6	C9	0.0031	0.0021	356	22	43	196.9421	1:	63960	0.0011	1.09
TOWER	A2	0.0030	0.0021	5	33	48	143.6213	1:	47582	0.0009	1.74
TOWER	A5	0.0032	0.0025	23	7	3	203.5244	1:	64241	0.0011	1.25
TOWER	A9	0.0034	0.0029	48	1	39	260.8854	1:	76897	0.0013	1.00
TOWER	B2	0.0030	0.0019	26	41	37	183.3184	1:	60256	0.0011	1.10
TOWER	B5	0.0035	0.0024	25	8	16	222.1546	1:	63479	0.0012	1.15
TOWER	B9	0.0036	0.0029	34	35	55	267.9666	1:	73641	0.0014	1.03
TOWER	C2	0.0034	0.0017	31	2	19	220.0437	1:	65491	0.0013	0.78
TOWER	C5	0.0040	0.0024	20	45	30	247.5546	1:	62480	0.0014	1.08
TOWER	C9	0.0040	0.0032	23	5	25	289.0069	1:	72797	0.0015	1.06
A2	A5	0.0026	0.0013	346	43	48	61.0660	1:	23135	0.0006	3.51
A2	A9	0.0027	0.0017	343	32	43	119.2720	1:	44953	0.0008	1.80
A2	B2	0.0022	0.0011	344	48	46	62.2274	1:	28756	0.0008	2.10
A2	B5	0.0029	0.0014	353	10	20	84.1052	1:	29204	0.0007	2.62
A2	B9	0.0030	0.0018	348	3	10	125.2262	1:	41867	0.0007	2.00
A2	C2	0.0023	0.0012	354	50	17	113.7200	1:	49562	0.0009	1.05
A2	C5	0.0034	0.0014	356	27	59	121.3948	1:	35714	0.0011	1.75
A2	C9	0.0035	0.0020	345	56	13	151.3692	1:	43043	0.0009	1.89
A5	A9	0.0017	0.0012	337	41	58	58.2204	1:	33994	0.0005	2.34
A5	B2	0.0023	0.0012	349	50	44	73.1120	1:	32014	0.0009	1.56
A5	B5	0.0022	0.0011	349	56	8	53.8391	1:	24872	0.0009	1.91
A5	B9	0.0021	0.0013	344	9	14	72.7820	1:	34436	0.0006	2.34
A5	C2	0.0023	0.0011	353	40	6	115.6378	1:	50002	0.0009	0.84
A5	C5	0.0028	0.0011	353	45	29	100.1753	1:	36185	0.0011	1.06
A5	C9	0.0028	0.0015	342	15	18	108.5288	1:	38877	0.0008	1.90
A9	B2	0.0023	0.0015	341	37	19	117.9332	1:	50837	0.0008	1.29
A9	B5	0.0021	0.0011	341	41	45	77.8360	1:	37022	0.0008	1.42
A9	B9	0.0019	0.0010	337	40	17	50.2000	1:	26116	0.0007	2.02
A9	C2	0.0024	0.0014	342	24	46	145.3818	1:	61649	0.0009	0.86
A9	C5	0.0028	0.0011	347	27	6	113.4053	1:	41078	0.0011	0.87
A9	C9	0.0027	0.0011	338	3	14	91.8619	1:	34189	0.0010	1.48
B2	B5	0.0024	0.0011	354	28	2	46.5972	1:	19251	0.0005	4.23
B2	B9	0.0026	0.0015	344	32	46	97.7287	1:	38033	0.0007	2.07
B2	C2	0.0014	0.0010	358	22	7	51.7584	1:	36751	0.0006	1.61
B2	C5	0.0029	0.0011	356	40	30	64.7389	1:	22246	0.0007	3.33
B2	C9	0.0031	0.0016	341	22	30	107.6636	1:	34874	0.0007	2.40
B5	B9	0.0023	0.0011	341	14	44	51.1344	1:	22547	0.0006	3.39
B5	C2	0.0023	0.0011	355	44	34	68.1954	1:	29425	0.0009	1.70
B5	C5	0.0027	0.0009	351	52	30	46.3441	1:	17250	0.0011	2.18
B5	C9	0.0028	0.0013	338	58	57	67.5592	1:	23954	0.0005	3.49
B9	C2	0.0025	0.0013	342	29	44	108.2977	1:	43490	0.0009	1.37
B9	C5	0.0027	0.0010	345	5	26	69.4894	1:	25344	0.0010	1.73
B9	C9	0.0027	0.0010	335	22	49	42.2147	1:	15377	0.0009	3.66
C2	C5	0.0027	0.0010	356	35	23	43.4181	1:	15933	0.0006	4.96
C2	C9	0.0029	0.0014	338	17	0	96.9524	1:	32874	0.0009	2.15
C5	C9	0.0031	0.0011	341	7	36	53.5811	1:	17128	0.0008	4.20